#18 Declaration 5/25/04

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: **DeSALVO ET AL.**	Examiner: H. Phan
Serial No. **09/724,256**	
Filing Date: **November 28, 2000**	
Confirmation No. **7913**	Art Unit: 2633
For: **OPTICALLY AMPLIFIED RECEIVER**	

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SUPPLEMENTAL DECLARATION UNDER 37 C.F.R. 1.131

Mail Stop Amendment
Commissioner for Patents
P. O. Box 1450
Alexandria, VA 22313-1450

Sir:

We, **JOHN DeSALVO, MICHAEL LANGE, SCOTT BRICKER, RANDALL K. MORSE and JANE CLAIRE WHITE**, hereby declare:

1. We are the joint inventors of claims 1-31 of U.S. patent application serial no. 09/724,256 identified above, and the subject matter described and claimed therein. This Supplemental Declaration is submitted to supplement the original Declaration Under 37 CFR §1.131 filed in response to the Office Action mailed August 13, 2003, in which we conclusively showed that we had conceived and reduced to practice the claimed invention before September 30, 1998, the effective date of U.S. Patent No. 6,384,948 to Williams et al. In the subsequent Office Action mailed February 6, 2004, the Examiner rejected most claims as obvious over U.S. Patent No. 6,366,376 to Miyata et al., filed December 31, 1998 (based on a continuation application filed on

February 14, 1997), in view of U.S. Patent No. 5,854,704 to Grandpierre filed June 25, 1997. This Supplemental Declaration resubmits sheets 1-8 that were originally submitted in the previous Declaration and adds new sheets 01 and 1A. Sheet 01 is an earlier page from an inventor's laboratory notebook than original sheet 1, filed in the original Declaration. Sheet 01 shows an earlier date of conception.

2. Prior to February 14, 1997, the effective date of cited U.S. Patent No. 6,366,376 to Miyata et al., we had conceived our invention that is described and claimed in the above-identified patent application while working in the United States in the Palm Bay, Florida facility of Harris Corporation. We worked diligently on developing the claimed invention from the time of conception to reduction to practice at a date after February 14, 1997, but before September 30, 1998. From the time of reduction to practice to the filing of the above-identified patent application, we worked diligently on developing a commercially feasible optically amplified receiver of the present invention.

3. Before February 14, 1997, joint inventors, DeSalvo, Lange and Bricker, had initially worked on the development of a structure and circuit for optically amplifying signals to deliver a clean current source through an injection laser diode as part of an optically amplified receiver that optimizes a system and is incorporated into a single assembly. Joint inventors, DeSalvo, Lange and Bricker, were later joined by joint inventors, Randall K. Morse and Jane Claire White, to

design and reduce to practice an improved optically amplified receiver based upon the initial research of joint inventors, DeSalvo, Lange and Bricker.

4. Before February 14, 1997, we conceived an optically amplified receiver using an optical preamplifier, bandpass filter, PIN detector and amplifier circuit. Initial conception drawings are shown in the laboratory notebook sheets 01, 1, 1A and 2 of Exhibit 1 attached hereto. Sheet 01 is the earliest sheet from the laboratory notebook and shows the initial conception drawing, with a WDM line having different wavelength signals. A portion of the signal branches off into a separate line through an optical broadcast node shown by the large dot. This branch signal line passes through a first and second erbium doped fiber amplifier, i.e., an optical preamplifier. The optical communications signal is split through an optical demultiplexer and passes through bandpass filters that receive and select the signal channel and filter out noise. A PIN detector shown as a diode receives the optical communications signal from the bandpass filter and converts the optical communications signal into an electrical communications signal. Sheet 1A shows numerical figures about the variable erbium doped fiber amplifier preamplifier gain. Sheets 3-7 of Exhibit 1 also show the development and the initial conception of the optically amplified receiver. As evident and as set forth in the previously submitted Declaration, Exhibit 1 clearly shows the work resulting in an optical preamplifier for receiving an optical communications signal over a fiber optic communications

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Filing Date: **11/28/2000**
______________________________/

line. The bandpass filter receives the signal and selects the signal channel and filters out noise. A PIN detector receives the optical communications signal from the bandpass filter and converts the optical communications signal into an electrical communications signal. An amplifier circuit amplifies the electrical communications signal. Sheet 7 shows a technical memorandum that was written by one of the joint inventors.

5. The joint inventors worked diligently to reduce to practice this invention from the time of conception and tested the invention as shown by the receiver sensitivity experiment on sheet 8 of the laboratory notebook in Exhibit 1 after February 14, 1997, but before September 30, 1998.

6. The dates are deleted on the sheets from Exhibit 1 and all dates are prior to September 30, 1998.

7. We hereby declare that all statements made herein of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

5/7/2004
Date

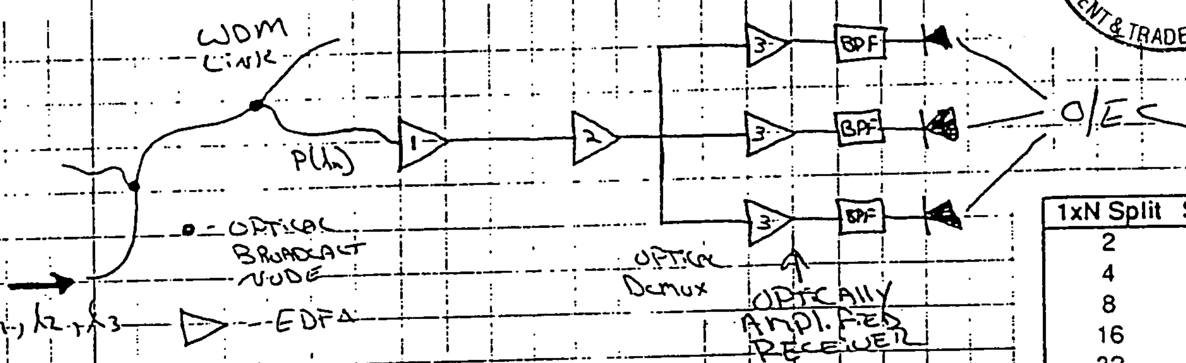
JOHN DeSALVO

In re Patent Application of:
DeSALVO ET AL.
Serial No. **09/724,256**
Filing Date: **11/28/2000**

MAY 6, 2004	Michael R. Lange
Date	**MICHAEL LANGE**
5/7/04	Scott M. Bricker
Date	**SCOTT BRICKER**
5-10-04	Randall K. Morse
Date	**RANDALL K. MORSE**
5/7/04	Jane C. White
Date	**JANE CLAIRE WHITE**

8

EDFA Study 1377-0200



1xN Split	Split Loss (dB)
2	3
4	6
8	9
16	12
32	15
64	18

$\boxed{\text{BPF}}$ - OPTICAL Band-PASS Filter

Amplifier Characteristics
1. ~~[illegible]~~-Noise Figure
2. Output Power
3. Gain
- Gain Flattening
- Gain Shaping

Receiver Topology
- Filter Techniques

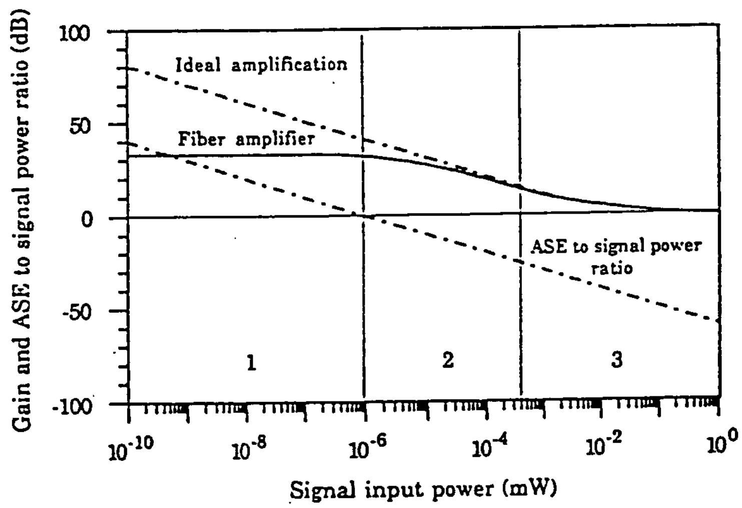


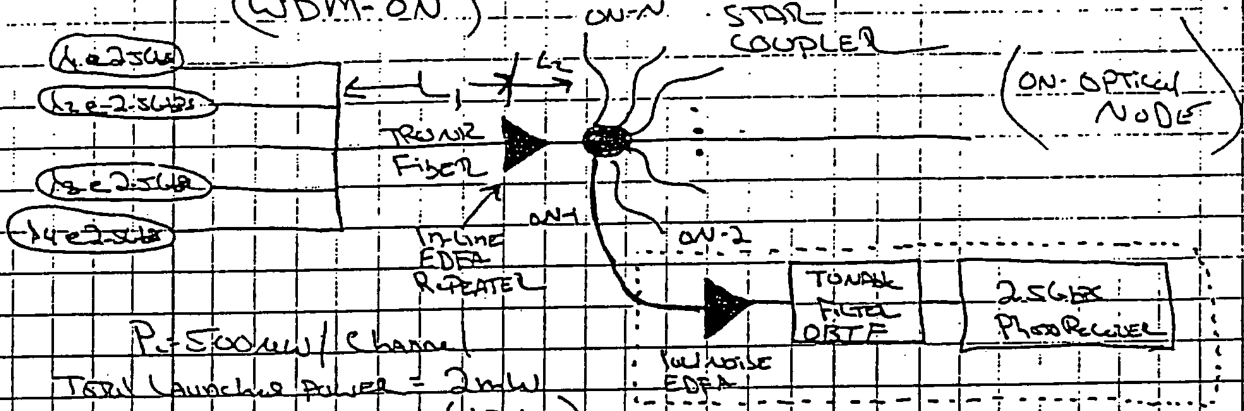
Figure 6.1 Gain- and ASE-to-signal ratio for fiber pumped with 20 mW at 1480 nm [1].

01

D. [signature]

Low-Noise WDM Receiver

Wavelength-Division Multiplexer Optical Network (WDM-ON)



WDM Receiver

P = 500uW/Channel

Total Launched Power = 2mW (+3dBm)

L_1 - Fiber Span to first Repeater EDFA (Assume 50 km Spans) $\alpha L = (0.2\,dB/km)(50)$ ($\alpha L = 10\,dB$)

L_2 - Fiber length between Star coupler and EDFA Repeater ($L_2 \ll L_1$)

1x64 Star Coupler - 18 dB Loss Fixed -18 dB

L_{ex}	-2 dB	excess optical loss per span x2	-4dB
L_{scx}	-0.5 dB	excess Star coupler insertion loss	-0.5
L_{bp}	-2.0 dB	OBTF insertion loss	-2.0
			-24.5 dB

The WDM Receiver is capable of accepting multiple optical channels on a single fiber, amplifying them one each channel as single channel as shown above, or demultiplexing them into individual channels for simultaneous recovery. The optical amplifier is used to provide high sensitivity, probably better than any APD.

Dean [signature]

80 & COMPUTER CODE w/ BACK ANALYSIS

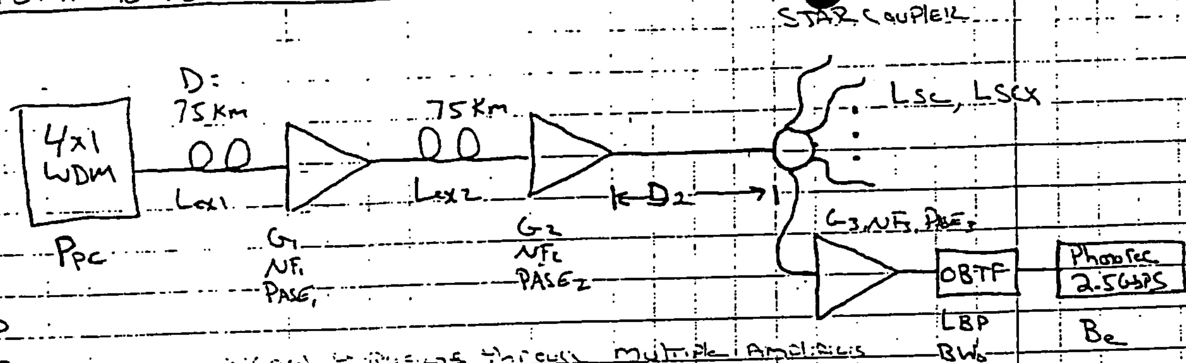

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% VARIABLE EDFA PRE-AMPLIFIER GAIN
%% Richard DeSalvo
%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
clear
e    = 1.60217733e-19; % elementary charge (C)
h    = 6.6260755e-34;  % Plank's constant (J*sec)
c    = 2.99792458e+8;  % speed of light (m/s)
k    = 1.380658e-23;   % Boltzman's constant (J/K)
T    = 300;            % absolute temperature (K)
lr   = 1552.5e-9;      % ITU Draft recomendation
                       % for reference wavelength(nm) (193.1 THz)
hnu = h*c/lr;
Nch = 4;               % Number of channels
deltal = 1.0e-9;       % channel spacing (nm)
df = c*(deltal/lr^2);  % channel spacing (Hz)
l=zeros(size(1:Nch));
for j = 1:Nch,
   f = 193.1e12 + df*(j - (Nch/2 + 1));
   l(j) = c/f;         % WDM channel center wavelengths (m)
end
Pc   = 250.0e-6;       % avg. optical power per channel (W)
Pt   = Nch*Pc;         % composite optical power (W)
RIN  = -135;           % laser RIN (dB/Hz)
r    = 10;             % Tx extinction ratio (dB)
a    = 0.25;           % attenuation coefficient at 1550 nm (dB/km)
Ns   = 2;              % Number of fiber spans
D1   = 75;             % fiber span between repeaters (km)
D2   = D1/2;           % max fiber length between repeater and star coupler (km)
Nu   = 64;             % total optical nodes per star coupler

%%% OPTICAL LOSSES
Ls   = -a*D1;             % optical loss per span (dB)
Ltx = -a*D2;              % fiber loss to star coupler (dB)
Lex  = 0.0;               % excess optical loss per span (dB)
Lsc  = -10*log10(Nu);     % optical splitting loss from star coupler (dB)
Lscx = -4.0;              % excess loss in star coupler (dB)
Lct = Lsc + Lscx          % total coupling loss (dB)
Lbp = -2;                 % EDFA OBTF insertion loss (dB)
Lst  = Ns*Ls;             % Total fiber attenuation loss (dB)
Lext  = Ns*Lex;           % Total excess loss (dB)
Lt = Lst + Lext + Ltx +...
     Lsc + Lscx;          % Total path averaged optical loss (dB)
Lr = Ltx + Lsc + Lscx +...
     Lext;                % Optical node Routing loss to EDFA pre-amp(dB)
Gt   = -Lst;              % Total Tx system EDFA gain (dB)
Gr  = -Ls;                % Repeater EDFA optical gain (dB)
NFr = 5.5;                % Repeater EDFA noise figure (dB)
Bor = 30;                 % Rep. EDFA optical bandwidth (nm)
BWr = c*(Bor*1e-9)/lr^2;  % Rep. BW (Hz)
%%% TRANSMISSION SYSTEM LOOP TO CALCULATE ASE POWER
Pspo = 0; % counter for ASE power loop
for o = 1:Ns,
   Psp = (0.5*10^(0.1*NFr))*(10^(0.1*Gr)-1)*hnu*BWr;
   PspT = Psp + Pspo*10^(0.1*Ls)*10^(0.1*Gr)*10^(0.1*Lex);
   Pspo = PspT;
end  %% ASE POWER LOOP

%%% OPTICAL POWERS AT EDFA PRE-AMP INPUT
Pavg = Pc*10^(0.1*(Ns*Gr + Lt)); % Avg optical power (W)
PavgdB = 10*log10(1000*Pavg);    % Avg opt. power (dBm)
PM   = 2*Pavg*10^(0.1*r)/...
       (10^(0.1*r) + 1);         % Mark power (W)
PS   = 2*Pavg/...
       (10^(0.1*r) + 1);         % Space power (W)
Pase = PspT*10^(0.1*(Lr-Lext));  % ASE power (W)
%% WDM RX PRE-AMP GAIN LOOP
```


1A

POINT-TO-POINT WDM LINE ANALYZED



P_{pc} = Avg. 4P optical power per WDM chan.

L_{ex} = excessloss per span

D = Fiber span between repeaters

Signal propagates through multiple amplifiers seems to build the noise background

1) $P_{ASE} = N_{sp}[G-1]\,h\nu B_o$

2) TOTAL ASE POWER OUT OF 2nd in-line EDFA

$P_{sp,T} = P_{ASE2} + P_{ASE1}\,e^{-\alpha D} + e^{\alpha D} + L_{ex}$

$C = .5(1 - 10^{-\frac{\alpha L}{10}})$

$\underline{-19.4\,dB}$

$D_2 \leq D/2$ (Bounding Parameter)

$L_1 = e^{\alpha D}$, $\alpha = 0.2$ dB/Km

$L_2 = e^{\alpha D_2}$

} Fiber attenuation losses

$L_{sc} = -10 * \log_{10}[N_U]$, N_U = # of users for star coupler

L_{scx} = Excess loss in star coupler

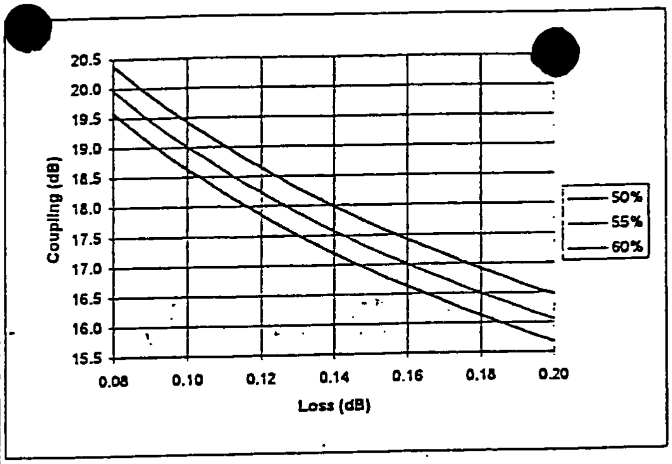
- In-line amplifiers compensate only for fiber attenuation loss $\Rightarrow G = e^{\alpha D_x}$. Therefore, the signal power out of the EDFA is equal to its value at the beginning of the span.

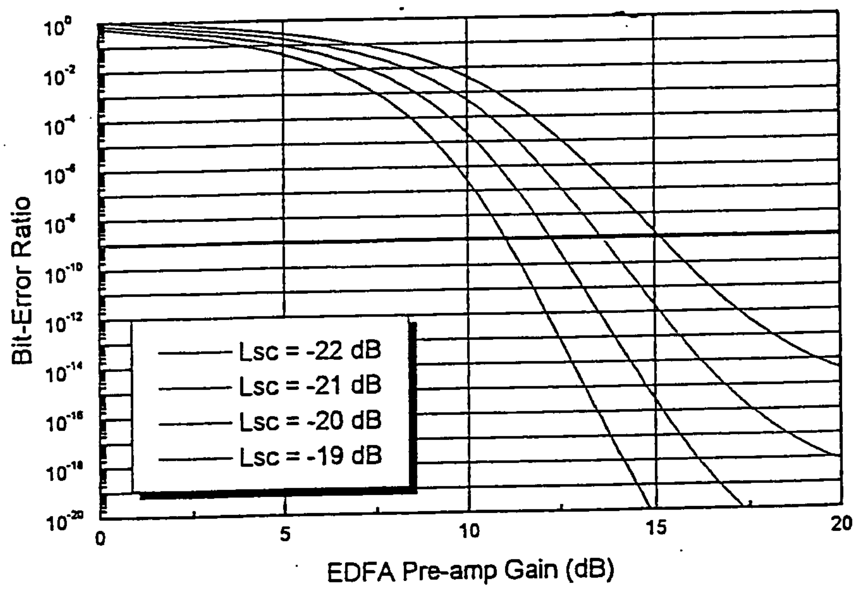
- Routing loss is defined as the total loss to the signal that occur immediately following the last in-line EDFA in addition to the excess losses occuring in the trunk lines that are not compensated by the in-line EDFA gain.

$$L_R = L_{ex} + e^{-\alpha D_2} + L_{sc} + L_{scx}$$

- There is one last loss element between the EDFA preamplifier and the photodetector, the tunable optical bandpass filter, LBP

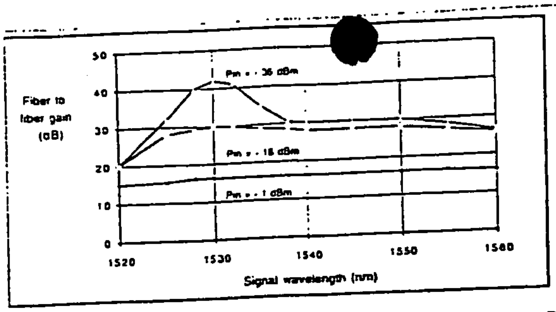
Loss (dB)	Coupling @ CE=50%	Coupling @ CE=55%	Coupling @ CE=60%
0.080	20.4	20.0	19.6
0.085	20.1	19.7	19.3
0.090	19.9	19.5	19.1
0.095	19.7	19.2	18.9
0.100	19.4	19.0	18.6
0.105	19.2	18.8	18.4
0.110	19.0	18.6	18.2
0.115	18.8	18.4	18.0
0.120	18.7	18.2	17.9
0.125	18.5	18.1	17.7
0.130	18.3	17.9	17.5
0.135	18.2	17.7	17.4
0.140	18.0	17.6	17.2
0.145	17.8	17.4	17.1
0.150	17.7	17.3	16.9
0.155	17.6	17.1	16.8
0.160	17.4	17.0	16.6
0.165	17.3	16.9	16.5
0.170	17.2	16.8	16.4
0.175	17.0	16.6	16.3
0.180	16.9	16.5	16.1
0.185	16.8	16.4	16.0
0.190	16.7	16.3	15.9
0.195	16.6	16.2	15.8
0.200	16.5	16.1	15.7

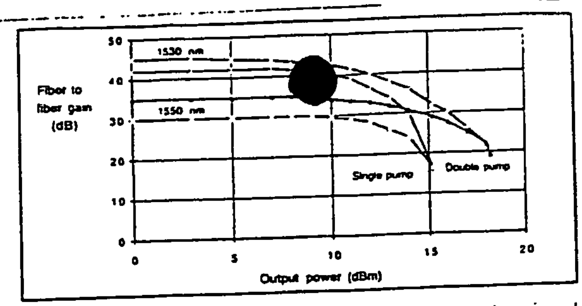




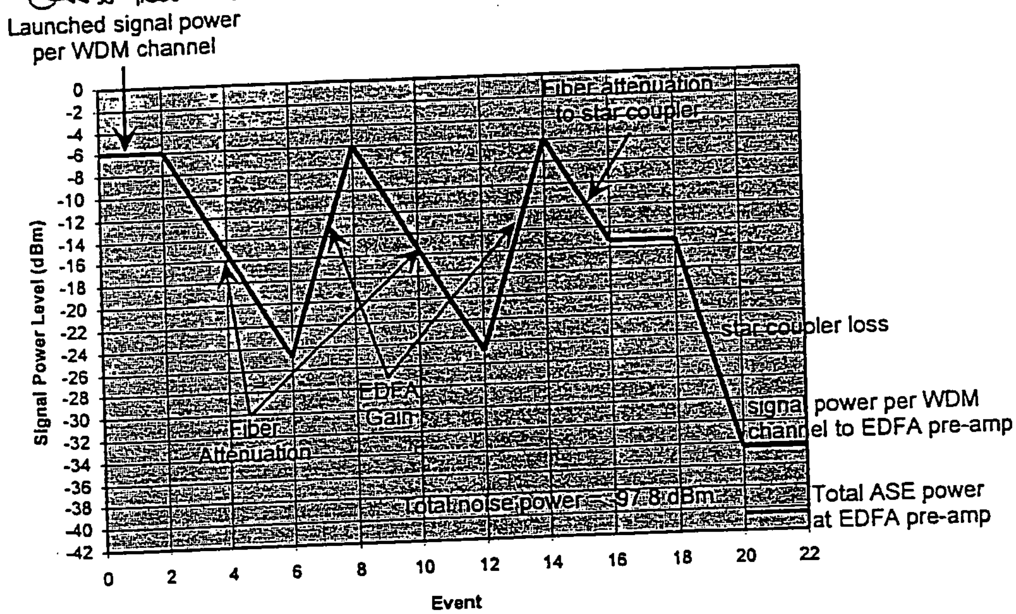
The condition/Assumption used in the analysis are:

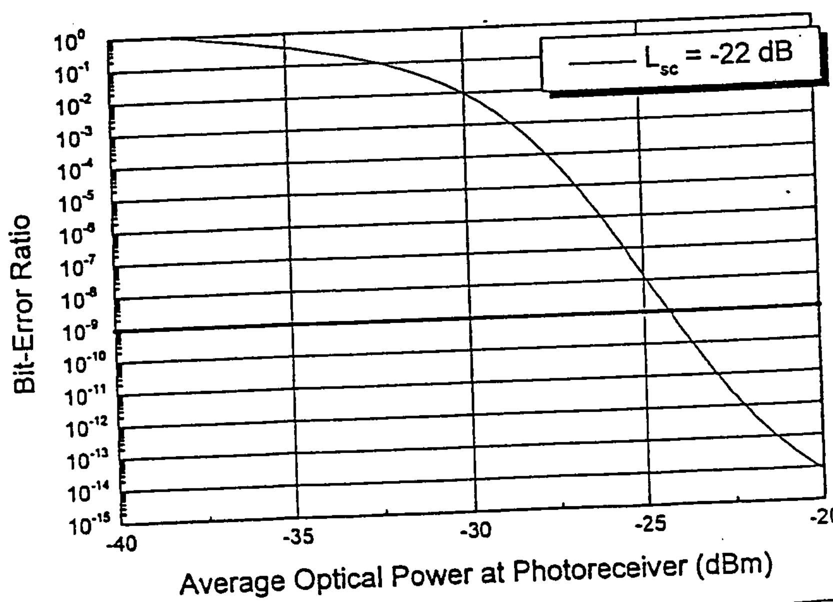
- $L_{ex}=0$, the in-line amplifier compensate for any small loss that occur in a span
- $L_1 = -18.75$ dB ⇒ the in-line EDFA must provide at least 18.75 dB of gain per WDM channel. The noise figure of the in-line EDFA was fixed at 5.5 dB
- D_2, the maximum distance the star coupler can be placed from an in-line EDFA is $D_1/2$. Therefore, the signal level (i.e. the launched power per channel) will drop by 9.4 dB (no more than).
- WDM signal is distributed to the optical nodes via a 64 channel star coupler with loss, $L_{sc} = -18$ dB, excess losses (coupler efficiency) are to be assumed in the 1 to 3 dB range.
- A representation of the system power budget showing the signal power level per WDM channel at the EDFA pre-amp input is shown on the next page.



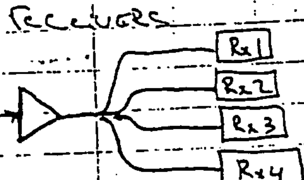


Graphical Representation of WDM System Power Budget



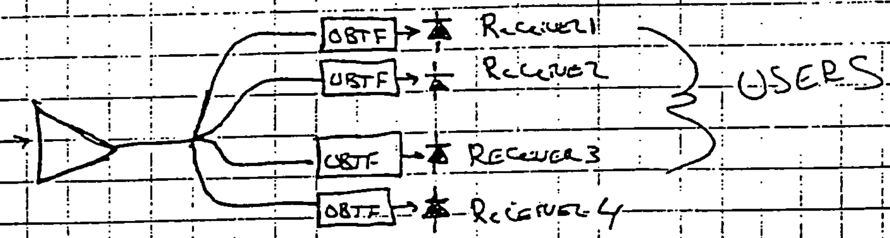


To simultaneously recover the 4 WDM signals, the optical signal out of the EDFA preamp must be split 4-ways to individual receivers.

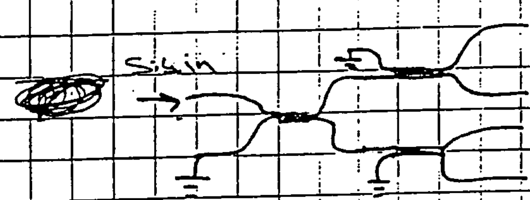


We'll use the worst-case coupling loss of -22 dB for this analysis. Trading the de-multiplexing topology, EDFA pre-amp gain, and the addition of another EDFA used to compensate for the additional splitting losses if the pre-amp gain alone is not adequate

POWER SPLITTER / OPTICAL BANDPASS TUNABLE FILTER De-MULTIPLEXER



POWER SPLITTER: CASCADED 3-dB COUPLERS



MINIMUM INSERTION LOSS = −6 dB
TYPICAL IL = −7 dB

OBTF characteristics are the same as in the analysis, i.e. approx 2 dB insertion loss and tunability over the input signal wavelength range. Assume the loss is independent of ~~[illegible]~~ center wavelength.

ADVANTAGES

- Variable signal wavelength
  - Reconfigurable Network
  - Add/Drop multiplexing
- User ~~[illegible]~~ selectable signal band
  - WDM distribution network

DISADVANTAGES

- Lossy

For 20 dB preamp gain, including a power splitter w/ −7 dB insertion loss would result in ~~[illegible]~~ $BER = 3\times10^{-6}$

To achieve a ~~[illegible]~~ minimum $BER = 10^{-4}$, the EDFA pre-amp gain would only need to be increased to $G = 22.2$ dB

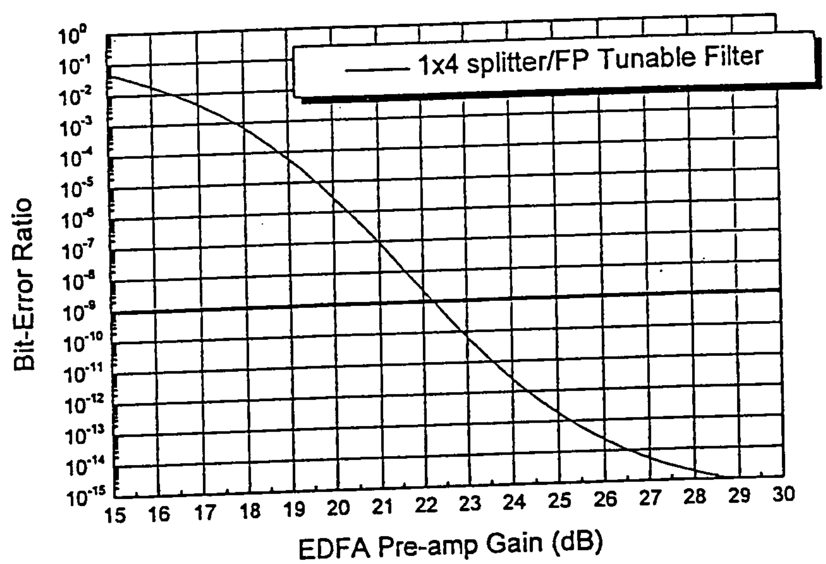
SEE PLOT ON FOLLOWING PAGE

Tunable Fabry-Perot Etalon Filter

		Oper. λ	FSR	BW	F	IL
JDS Fitel	TB2500M	1520-1570	50-85	.4-[illegible]	100	<2.5
	TB2500-CB Tracking Filter	"		.2-1.0	40-100	<5
	TB2500-EC Controller Unit					

Micron Optics In-line Fiber FP filters Total loss <2 dB

Santec



Electrical Power Dissipation Issue
- Phoned Olivier Guy @ Photonetics (617) 245 2333
- Gave him Lucent's spec. values for a compatible amplifier
- Will fax France to ask about reducing the dissipated electrical power

See page 88 regarding fax-back from France

Technical Memorandum
JA 4139-0301

Title: Sensitivity Calculation for an EDFA Pre-Amplified pin Photodetector Receiver

Author: Richard DeSalvo

1.0 Introduction

This memo summarizes the analysis performed in calculating the receiver sensitivity for an erbium-doped fiber optical pre-amplifier and pin photodetector. The receiver is assumed to operate at 2.488 Gb/s. The EDFA is modeled after the OptiGain Model 4012 optical pre-amplifier and the receiver module is modeled after the Sumitomo SDT 8908-R-Q fiber optic receiver module. The analysis is based on Chapter 3, "Photodetection of optically amplified signals," in Desurvire's <u>Erbium-Doped Fiber Amplifiers - Principles and Application</u>. A block diagram describing the components modeled and their appropriate parameters is shown in Figure 1.

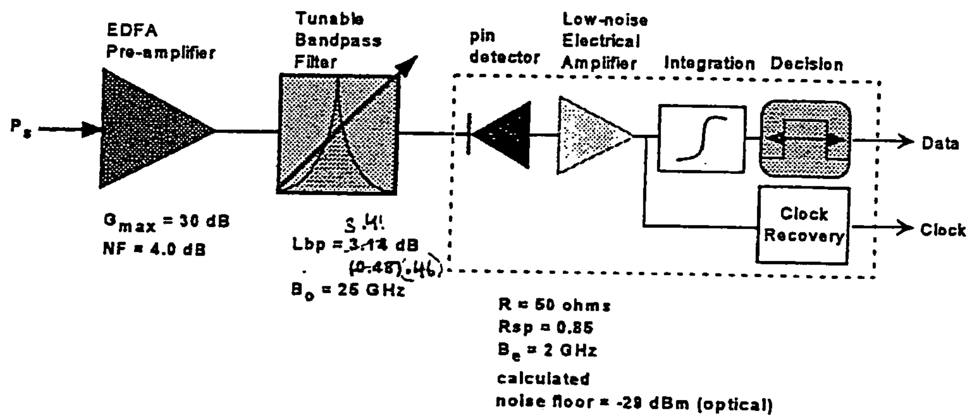


Figure 1 Block diagram representation of an OPA + D receiver with parameters used in the sensitivity model presented.

RECEIVER SENSITIVITY EXPERIMENT

Photonetics EDFA

Calculated $\overline{P} = -40.8$ dBm

Theoretical $\overline{P} = -47.1$ dBm

$G_{ss} = \cancel{31}$ 27 dB , NF = 4.5 dB

O/P coupling loss ~~3.37~~

OTF B_O = 25 GHz

IL = 4.92 dB

B_e = 2 GHz NP = -29 dBm

K_{o1} = 13 dB

MEASURED $\overline{P} = -39.7$ dBm

Using OPTIGAIN EDFA, we measure a Receiver Sensitivity $\overline{P} = -41.5$ dBm

$$-41.5 \text{ dBm} = \frac{\cancel{2.818}\ 7.08 \times 10^{-8}\ W\left(\frac{J}{sec}\right)}{h\nu(J)} = \frac{\#\ \text{Photons}}{\text{Sec}}$$

$$h\nu = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34}\ J\cdot sec \cdot 3 \times 10^{8}\ m/s}{1550 \times 10^{-9}\ m} = 1.28 \times 10^{-19}\ J$$

$$= \frac{\cancel{2.2}\ 5.5 \times 10^{11}\ \text{Photons/Sec}}{2.488 \times 10^{9}\ b/s} = \cancel{88}\ 222\ \text{Photons/Sec}$$

Dan [signature]